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SANITIZED VERSION OF OPERATION OF THE SIDE PURGE
(From CRD Document # A-4185, dated 6/11/47)

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Environmental Management Division
OAK RIDGE K-25 SITE
for the Health Studies Agreement

July 1995

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CARBIDE AND CARBON CHEMICALS CORPORATION

Process Division

OPERATION OF THE SIDE PURGE

L. W. Anderson - T. E. Koprowski

and T. Shapiro

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CLINTON ENGINEER WORKS

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Process Division

OPERATION OF THE SIDE PURGE

L. W. Anderson - T. E. Koprowski

and T. Shapiro

ABSTRACT

A summary of the side purge operations is presented. The operations at 304-5 and 305-12 are described in detail. Recommendations to move the side purge from 305-12 to 304-5, based on recent 312 consumption data, is made. Investigation of replacing the 312 purge operations with cold trap operations is suggested.

C O N F I D E N T I A L

To: A. P. Huber

Date of issue: June 11, 1947

OPERATION OF THE SIDE PURGE

Introduction

Due to the inherent characteristics of the gaseous diffusion process, there is a continuous inleakage of contaminants such as G-74 and air to the cascade which must be removed from the plant stream at certain points for efficient operation.

In case of large leaks to the cascade it is necessary to remove the light contaminants which would cause large inventory displacements and mixing as they move to the top of the cascade.

History - 303-10 Arrangement

The original side purge was placed in service at building 303-10. The building was placed on direct recycle, having the top building block valves (A outlet and B inlet) closed and the bottom building block valves (A inlet and B outlet) opened. The A and B building bypass valves were opened.

The upflow to building 304-1 was restricted by partially closing the "A" sectional air controlled valve. By the use of such a control, 80 to 90% of the total light diluent inleakage was withdrawn from the top of building 303-10, through the Purge and Product Room in 303-10.

The purge rate was controlled by an air operated valve on the suction of the Beach Russ pumps in the Purge and Product Room. This Control Valve received it's operating signal from the differential pressure of the 6A pump on cell 3, 5 or 7 by means of a PRC. The PRC was adjusted to maintain a set differential pressure on the 6A pump, and thus establish a set light contaminant concentration on that stage.

At the time the K-303-10 side purge was in use, the average inleakage of light contaminants below K-303-10 was approximately 3000 scfd. Eighty to ninety per cent of this inleakage was removed, using this side purge set up. In the event of a sudden large inleakage, the upflow to K-304-1 could be cut off entirely by closing the "A" sectional Control Valve and thus purging all the inleakage at building K-303-10.

One of the disadvantages of this side purge set up was that for an 80% reduction in flow, which is necessary to remove 80 - 90% of light contaminants between buildings K-303-10 and K-304-1, approximately 12 stages of separation was lost. This resulted in a 0.5% reduction in product purity on a basis of 91240004 concentration. However, regardless of the upflow from K-303-10 side purge, the entire side purge was always connected with a 2.2% loss in output, since 42 stages were not used for productive separation no matter how the building was operated.

304-5 Arrangement

After operations had expanded to the point where all sections of the plant were on stream and the 312 purge section was started, it became possible to remove G-74 at other points in the cascade such as 304-5, 305-12, and at the top of the cascade itself, because these buildings are connected directly to the purge cascade. Since the operation of K-303-10 as a side purge necessitated removing the whole building from effective light metal separation, it was decided to move the purge point to a location where stage loss would be less, and utilize the 312 section for purging.

The point chosen was K-304-5 which was put into operation on November 29, 1945. The top cell in the building (cell 4) was placed on direct recycle; the light contaminants being drawn off to the K-312-3 purge building through the "A" spare outlet and 312 feed line. With the "A" normal building outlet closed the upflow was directed to K-305-1 from cell 6, K-304-5, through the even side of the K-304-5 evacuation header which was connected to the "A" normal line, into K-305-1. The "B" downflow and the stripped C-616 returned from the 312 purge building was directed into K-304-5, cell 4. (See Figure 1)

The change proved to be quite satisfactory since it was found that only cell 4 was necessary to separate all the G-74 so that only 6 stages of productive separation were lost as compared to 42 in K-303-10. This was considerably better than originally expected and resulted in a gain of about 2.0% in plant productivity at the time the plant was producing 91240004 material. With the side purge set up as explained above, the side purge rate was approximately 1200 scfd per day.

Although the stage loss due to non-productive stages in K-304-5 was satisfactory, it was later discovered that the restriction of upflow to K-305-1 caused by feeding through the four inch evacuation header resulted in a loss in productivity equivalent to 17 stages. This loss was calculated from the K-305-1 stage 1 Control Valve which was 86% closed. It was desired to have at least 30% upflow which would have resulted in a production loss of only four stages and a stage 1 Control Valve position of 78% closed.

Before attempting an account of how the above problem was handled, mention must be made of the operation of the Surge for Purge System in conjunction with the Side Purge. The Surge for Purge, employed the surge capacity provided by the "B" spare header from K-303-1 to K-306-7 and the intersectional cells at K-306-1, K-305-12, K-305-1, K-304-1, K-303-10 and K-303-1, a total volume of 16,470 cubic feet. As originally operated this capacity was kept at a minimum pressure by the use of the intersectional cell pump at K-305-1 which pumped the gases into the K-304-5 surge drums (See the attached drawing for schematic representation of flows). Therefore, it is evident that any changes made in the operation of either of the two systems had to be considered in the light of it's effect on the other system.

To eliminate the pressure drop resulting from use of the C-616 evacuation header as a feed line to K-305-1, the flow was directed from K-304-5.6 "A" outlet through the "A" bypass directly to the "A" normal line into K-305-1. The purge to 312 was maintained by feeding from the C-616 evacuation connection from cell 4 and to the "A" spare line to K-312-3. Although this attempt proved successful from the standpoint of increasing the upflow the desired amount, it was abandoned because in valving K-312-3 from the evacuation connection at cell 4, two stages of the cell were not utilized since the evacuation connections tie into the discharge of the 4A pump. Since the gases from the Surge for Purge were continuously evacuated into this same cell, frequently excessively large G-74 concentrations, between 80 to 100%, developed; which backed up to cell 6, the feed cell, thereby retarding the rate at which the Surge System could be evacuated.

After further experimentation, the desired results were obtained by reverting to the original method for feeding G-74 to K-312-3, i.e., through the "A" spare outlet. By throttling the "B" inlet to cell 6, sufficient flow was maintained through the feed line to K-305-1 as determined by control valve position, G-74 flow and high side pressure, as follows:

1) G-74 flow = K x High Side pressure x G-74 concentration

In K-304-5:

In K-305-1:

2) Interstage Flow

(a) Average Control Valve positions

K-304-5	42.31
K-305-1	43.74

From calibration of Fischer and Republic flow control valves average interstage flow:

K-304-5

K-305-1

3) Actual Upflow from K-304-5 to K-305-1:

Along with the problem of restricted upflow, consideration had to be given to the requisites of the 312 purge operation. In order to obtain the low pressures necessary for efficient use of the Surge for Purge, the pressure in K-304-5 surge drums and cell 4 was kept as low as possible, as the pumping capacity of the K-305-1 intersectional pumps was governed by this factor. At the same time, since the suction pressure of the 312 reciprocating pumps also depended upon the K-304-5.4 6A pump discharge pressure, a minimum pressure, satisfying the requisites of both systems, had to be attained. After starting the AC Booster pumps in the 312 section, it was found that by holding high side pressure in stage 6 of cell 4, the necessary minimum suction pressure (0.5 psia) for K-312-3 was maintained and the Surge for Purge pumps were able to evacuate that system to 0.4 psia. By means of a C-616 bleed from the B normal to the suction of the K-305-1 intersectional cell pump (See Figure 1), a higher compression ratio was maintained in these pumps and it was possible to evacuate the surge system to 0.15 psia. The purge system under these conditions was able to purge approximately 3400 scfd with about 40% G-74 concentration in cell 4, K-304-5 without splitting the cascade at this point.

Some of the benefits accrued as a result of moving the side purge, such as the productivity increase have already been mentioned; also, as a consequence of the incorporation of the new surge for purge system, it was possible to eliminate all the normal cold traps in Plant II and to purge cells to negligible concentrations of C-616 in a matter of minutes rather than hours, thereby cutting cell off stream time appreciably.

Evacuation of the surge system is nearly continuous, only during a large surge is it necessary to stop pumping from the intersectional cell, so that there is usually little or no delay involved when cells are to be purged.

Before the development of the surge for purge system, the process stream was continually subject to "slugs" of G-74 arising from the evacuation to the cascade of residual G-74 that is always present in cells that had been off stream for a period of time (due to normal seal inleakage, actuation of BOP's, instrument alignments, etc.). This situation was, of course, considerably alleviated when the residual G-74 could conveniently be evacuated to the surge system before charging a cell and putting it on stream.

The evacuation of the surge system is now automatically controlled (See Figure 2) and calls for little attention during operation, except when a large slug of light contaminant passes up the cascade. Under normal conditions the entire system could be evacuated to about 0.4 psia at the rate of 3400 scfd. This is true even if the surge system pressure is as high as 7 psia, which is seldom the case.

In light of the success attained so far in operating side purges at various points in the cascade, it might seem desirable to operate the side purges at more than a single point in the cascade at a time. This had been given some thought and the following information obtained concerning the operation of side purges at the various locations in the plant.

TABLE I*

(Side Purge, K-304-5)

(Top Purge, K-306-7)

	Optimum Pressure	G-74 Conc.	SCFd (App.)	Stage Loss	Productivity Loss
306-7	0.30	21.0%	900	12.0	0.016%
306-1	1.00	4.5%	650	-	-
305-12	0.56	2.4%	650	-	-
305-1	0.74	0.78%	300	4.8	0.030%
304-5	1.35	2.2%	1200	6.0	0.062%
				22.8	0.108%

TABLE II*

(Side Purges at K-304-5 and K-305-12)

(Top Purge, K-306-7)

	Optimum Pressure	G-74 Conc.	SCFD (App.)	Stage Loss	Productivity Loss
306-7	0.3	8.1%	350	12.0	0.016%
306-1	1.0	2.3%	100	.2	-
305-12	0.56	2.32%	650	6.0	0.031%
305-1	0.74	.81%	300	4.8	0.030%
304-5	1.35	2.23%	1500	6.0	0.062%
				29.0	0.139%

*NOTE: Data in Tables I and II based on 6940004 operation before addition of feed line on 305-12.6.

TABLE III*

(Side Purge, K-305-12)

(Top Purge, K-306-7)

	Optimum Pressure	G-74 Conc.	SCFD (App.)	Stage Loss	Productivity Loss
306-7	0.3	21.0%	900	12.0	0.016%
306-1	1.0	4.5%	650	0.2	0.0003%
305-12	0.5	6.6%	1850	6.0	0.031%
				18.2	0.0473%

From the above data it was believed that the most economical arrangement under normal conditions would be the operation of a side purge at 305-12 and a top purge at 306-7. However, it is mainly during an emergency such as a large inleakage or upon starting up after a constant frequency failure that operation of more than one side purge point would be of maximum utility.

Purge Arrangement at 305-12

The original valving in 305-12 for side purge was similar to 304-5. The top cell in 305-12 (cell 4) was put on direct recycle; the light contaminants were disposed of to the 312 section through the "A" spare outlet. (See Figure 3)

*NOTE: Data in Table III based on 6940004 operation before addition of ~~feed line on~~ 305-12.6

The surge system consisted of 303-1, 303-10, 304-1, 304-5, 305-1 and 306-1 tanks with the connecting "B" spare lines. The surge system was pumped out continuously by means of two pumps connected in series in 306-1.1 intersectional cell pumping into the "A" spare line of 306-1 joining with the 312 return line and entering the 305-12 tanks into cell 4. On November 23, 1946, 305-12 tanks were utilized in the surge system by closing off the 312 C-616 return to 305-12 tank and forcing it through C-216 crossover from "A" spare to "B" normal to 306-1 and then entering 305-12.6, bypassing cell 4. This was done to decrease enriched inventory holdup. Total surge system was 16,470 cubic feet. Finally, Plant II surge system was cut to 8,043 cubic feet, using 304-1,5, 305-1,12, 306-1 tanks and adjoining bypass lines to restrict operation within Plant II in line with the Diversion Control Program.

The intersectional cells are capable of evacuating the surge system to .15 psia with the aid of a C-616 bleed line to increase the compression ratio in these pumps. A set of mercoids were installed to open the C-616 bleed valve at a .6 psia pressure in the surge system (See Figure 3 for schematic representation of instrumentation and flow).

When side purge was in operation in 304-5, a series of tests were run using a thermal conductivity (T.C.) cell to control evacuation of the surge drums. This proved very satisfactory so that when the side purge was moved to 305-12, the T.C. cell was used to control the evacuation of the surge system. The T.C. cell works along the principle of the pirani gage except it depends upon gas composition and not pressure. The T.C. cell electrical output is converted to pneumatic impulses that opened and closed an air-controlled valve between 306-1 tanks and the two pumps in series in the 306-1 intersectional cell. A set point of a certain percentage of lights (40 - 60%) in 305-12.6 was controlled by the T.C. cell by means of this set up (See Figure 3).

Installation of a take-off line from the stage 1 "B" stream in 305-12.6 for 306 section feed was made to permit a greater stripping section for G-74 in connection with the problem of reducing the high corrosion rate in 312 by increasing the bottoms concentration to the side purge building (See attached Figure 3). This feed line was a 4" pipe connecting the utility riser with the piping between #1 converter and #1 Control Valve. This system was put in use on December 17, 1946. With the new feed line, it gave a total of 12 stages for G-74 stripping with normal upflow of G-74 and C-616 in 306-1.

Upflow of C-616 from 305 section into 306 section had to be taken into consideration to obtain the proper upflow of C-616 and sufficiently low G-74. A maximum of 3 - 5% of G-74 going into 306-1 could be tolerated without causing abnormal operations at the low pressures. Pressures in 305-12 were set at .4, except for cells 4, 6, and 8. Cell 4 was held at 1.00 psia, cell 6 at .75 and top stage of cell 8 at .6 psia. This was done to increase upflow into 306-1 and still permit the large G-74 slugs to be removed by the side purge without splitting the cascade at this point.

Using Fisher and Republic Control Valve Nomographs published in a report by Moore, Stoltenberg and Melkonian, August 25, 1945, the C-616 upflow was established as 87% of the interstage upflow at this point of the cascade. This corresponds to less than one stage production loss. Therefore, the total stage loss for both side purge and upflow production loss is approximately 12 stages.

On January 5, 1946, cells 4, 6 and 8 pressures were raised in K-305-12 and cell 3 of 306-1 was raised from approximately .8 to 1.5 psia. This was done to gain larger surge capacity for C-74 slugs going upstream. The bottoms concentration from 312 section was raised from 35% lights to approximately 95% lights. Concentration in cell 6 is kept at approximately 60% lights at all times in the top stages by means of the T.C. cell. Upflow of C-616 into 306-1 is approximately the same as before.

Recommendation

Since data on consumption in the 312 section has become available it appears that it would be more economical to operate the side purge at 304-5.

Cost of 305-12 side purge	
12 stages of productivity loss	$ 444 per day
312-2 consumption losses	$ 137 per day
Total	$ 581 per day

Cost of 304-5 side purge

12 stages of productivity loss	\$ 454 per day
312-2 consumption losses	\$ 43 per day
Total	\$ 497 per day

This would be possible with the installation of a line from "B" outlet of stage 1, 304-5.6 to the utility riser of the same cell and the installation of a thermal Conductivity cell in 304-5. Establishing the side purge at 304-5 would increase the G-74 concentration in the 306 section but with the improved control, Automatic Proportional Response, this should no longer be a serious consideration.

It is recommended that the installation at 304-5 be made and that the side purge be moved to 304-5 to effect the possible savings of \$84 per day or \$2520 per month.

Purging costs could be substantially reduced if the 312 purging operations could be replaced with cold trap operations. It is estimated that approximately \$24,000 per month in direct operating cost could be saved. Also, cold traps could be so designed that no Radiation Hazard would be involved, thus eliminating the possible radiation hazards in in the present 312 purge operations. The success of this proposal depends upon the ability of a cold trap to remove the last traces of C-616 gas from purge gases. Testing of present available traps is recommended and if no satisfactory trap is available, design of a trap for this application should be undertaken.

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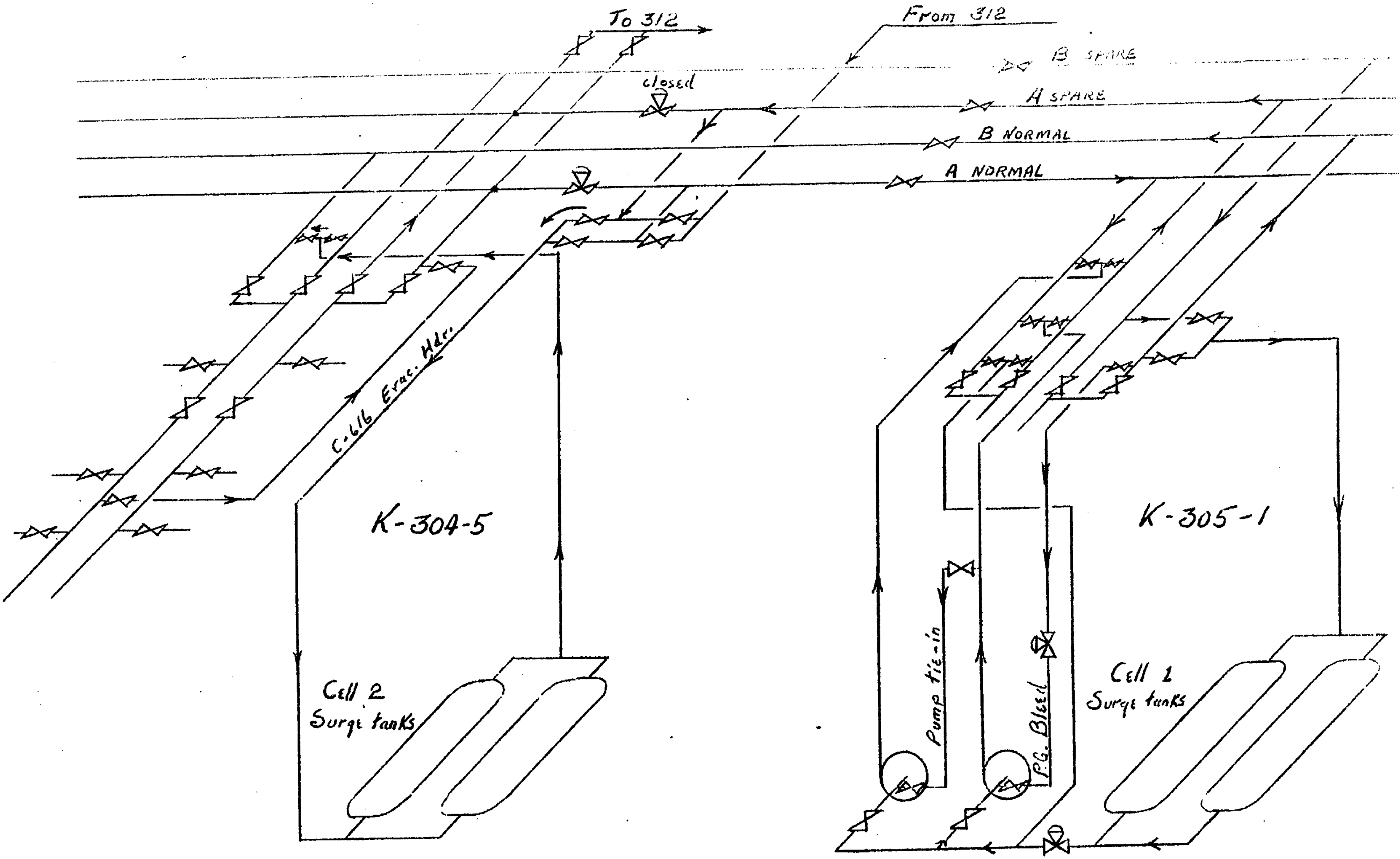
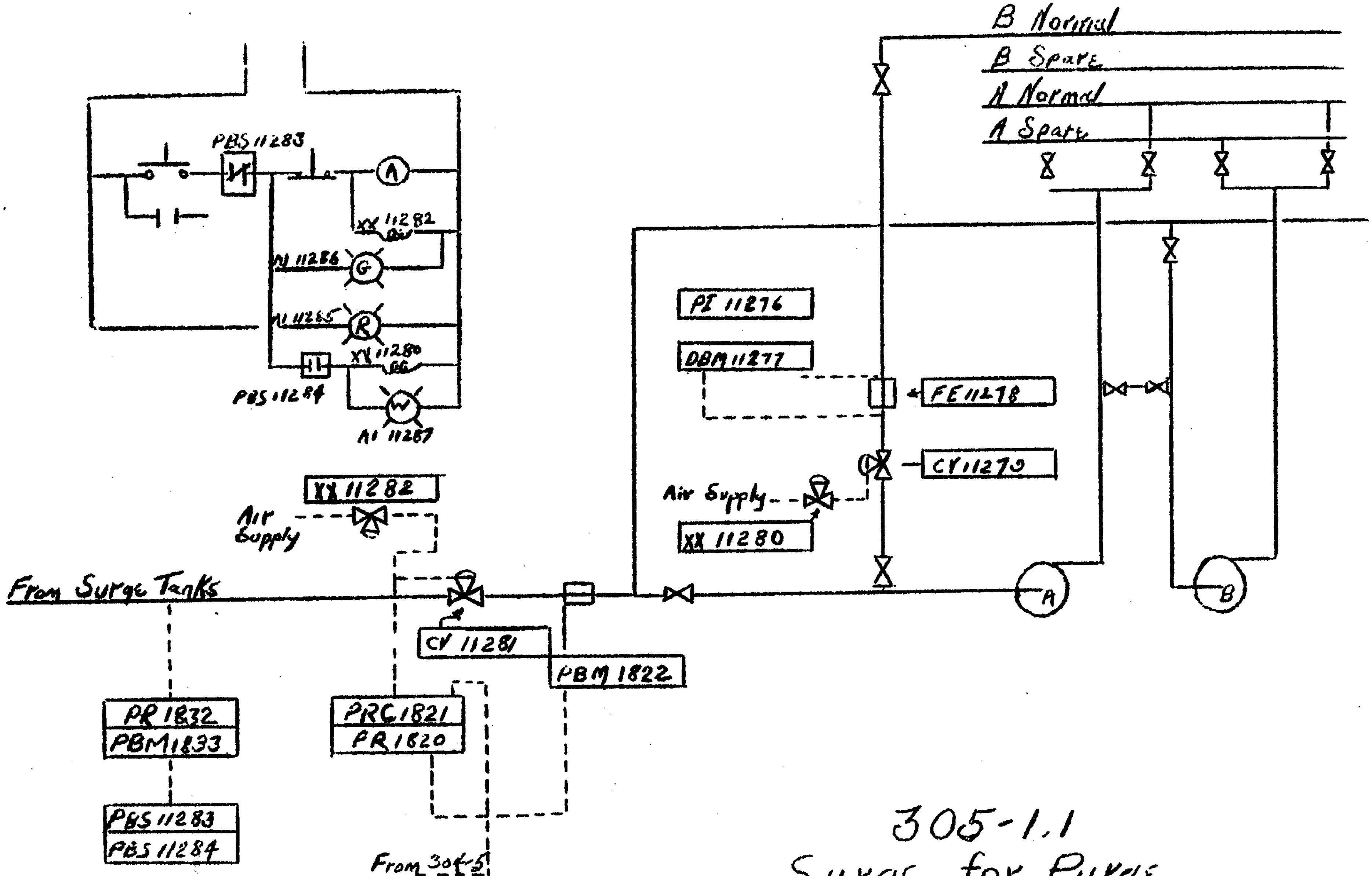


Figure 1

K-304-5 SIDE PURGE

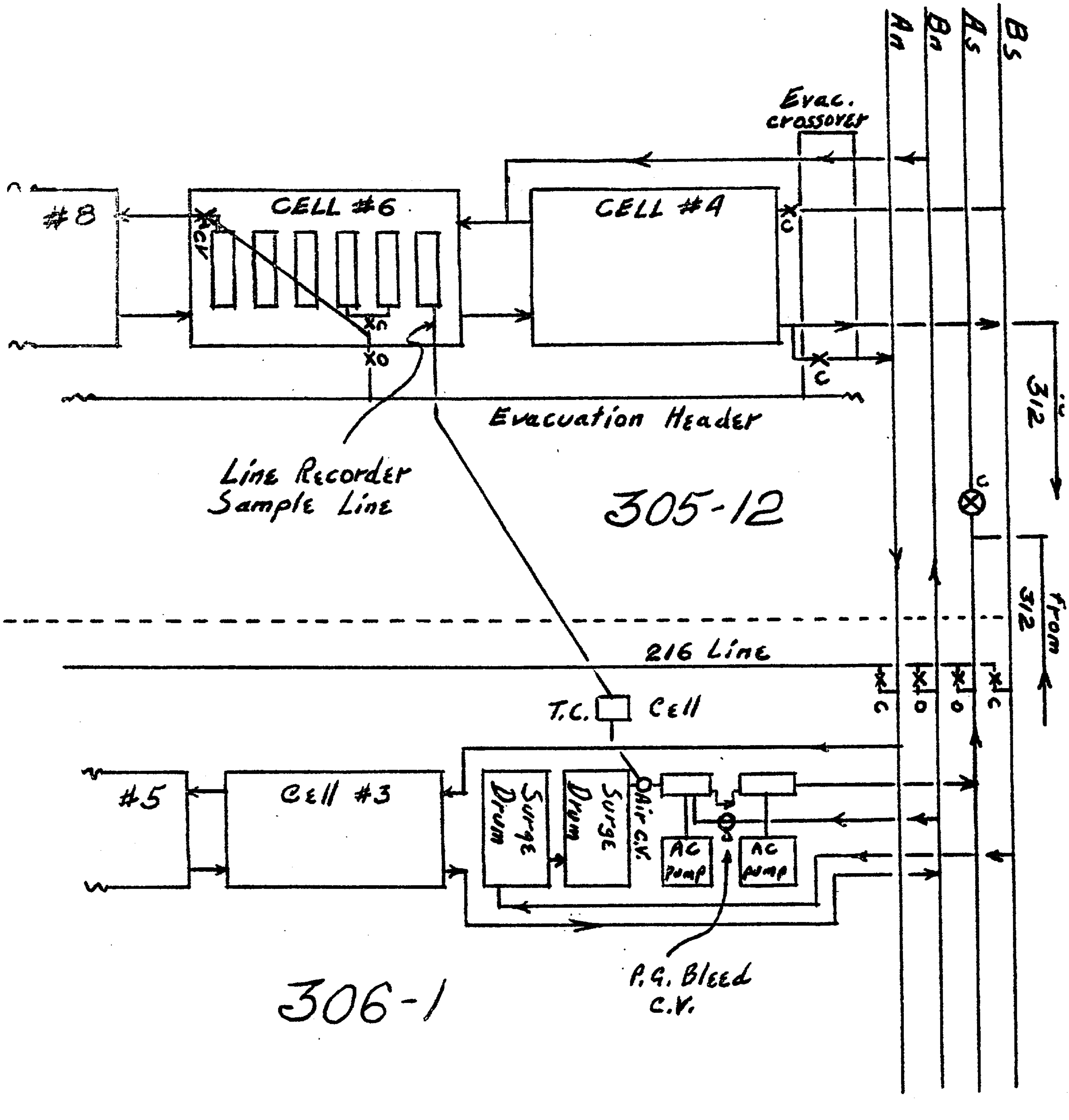
A.R. 6-4-42



305-1.1
Surge for Purge
Instrumentation

FIGURE 2

FIGURE 5



SIDE PURGE (305-12)
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